General Disclaimer

One or more of the Following Statements may affect this Document

- This document has been reproduced from the best copy furnished by the organizational source. It is being released in the interest of making available as much information as possible.

- This document may contain data, which exceeds the sheet parameters. It was furnished in this condition by the organizational source and is the best copy available.

- This document may contain tone-on-tone or color graphs, charts and/or pictures, which have been reproduced in black and white.

- This document is paginated as submitted by the original source.

- Portions of this document are not fully legible due to the historical nature of some of the material. However, it is the best reproduction available from the original submission.

Produced by the NASA Center for Aerospace Information (CASI)

"Made available under NASA sponsorship
in the interest of early and wide dissemination of Earth Resources Survey
Program information and without liability
for any use made thereof."

RECEIVED
NASA STI FACILITY
ACQ. BR.
JUN 16 1976
DCNF# 121910

E7.6-10372
CR-147965

LANDSAT Follow-on Investigation 28 600 x

Investigation of LANDSAT Imagery on Correlations between Ore Deposits and Major Shield Structures in Finland.

Quarterly Progress Report II
by Viljo Kuosmanen

Reporting Period Oct.-Dec. 1975

x
Principal Investigator:
Heikki V. Tuominen
Department of Geology
University of Helsinki
Snellmaninkatu 5
SF 00170 Helsinki 17
Finland

LANDSAT Follow-on Investigation 28 600 [x]

Investigation of LANDSAT Imagery on Correlations between Ore Deposits and Major Shield Structures in Finland.

Quarterly Progress Report II
by Viljo Kuosmanen

Reporting Period Oct.-Dec. 1975

[x]
Principal Investigator:
Heikki V. Tuominen
Department of Geology
University of Helsinki
Snellmaninkatu 5
SF 00170 Helsinki 17
Finland

ABSTRACT

A visual investigation of LANDSAT images has been carried out to study the image-textural features characteristic of different bedrock types and assemblages in Finland. A tentative classification of the textures is presented.

CONTENTS

INTRODUCTION

In the Baltic Shield several types of important ore deposits, and indications of ore, are distributed along or near major fracture zones. Owing to glacial drift cover, shallow topography and great the width of the zones (up to 50 km) these zones are not easily detected in the field by ground or airborne methods. The purpose of the investigation is to examine the expected advantages of LANDSAT imagery in exploring these structures. The test area (Fig. 1) for the study is representative of central part of the Shield.

The deep fractures of the Shield are generally faults separating blocks of different character. Owing to repeated rejuvenation they also form lineaments visible in the topography, vegetation, etc. On the other hand, there may be other prominent lineaments which result mainly from glacial flow.

Thus, for finding the deep fractures, it was considered necessary to look for boundaries between basement blocks of different constitution. During the reporting period attempts have therefore concentrated on finding out whether different bedrock units are distinguishable by textural differences in LANDSAT imagery.

The additional LANDSAT imagery received by the P.I. during the reporting period is listed in Table 1, and their coverage is shown in Fig. 1. All the LANDSAT-1 and LANDSAT-2 images of fair quality so far received have been utilized in the present study.

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

TECHNIQUES

LANDSAT images have been transmitted by NASA to Finland since 1972. By now a sufficient amount of reasonably fair images have been received for compilation of preliminary photomosaics covering most of Finland. MSS band 7 has been used for the mosaics the scale of which is 1:500 000. Separate mosaics have been made for winter and summer. These mosaics are being used in a search for major fractures zones.

Optical and digital enhancement procedures for comparing LANDSAT imagery with various geophysical, geological and morphological maps (See Tuominen, 1975) have been continued. A computer procedure for making rose diagram maps has been developed.

ACCOMPLISHMENTS

Image-textures related to different bedrock types

The image texture varies from area to area. In many cases these differences seem to correlate with differences in the general type (or structure) of the bed rock. These relations were studied on 68 separated sites in southern Finland selected by comparing the summer imagery with geological maps. The selection was made on the basis of more or less uniform image texture and bedrock type deviating from that of the surroundings.

The characteristic image textures found in the 68 sites were tentatively classified into eight main types shown in Fig. 2. These image-texture types correspond roughly to certain drainage patterns defined by Parvis (1950) and were named accordingly. An example of each of the eight texture types, on band 7, is given in Figs. 3 to 9.

The following bedrock properties seem to be characteristic of the diffirent image textures.

1 Acid plutonic rocks, partly mimatitic with gneiss portions: angulate image texture (Fig.3) In the example the texture seems to be restricted to a triangular fault block. (South of Rautalampi, central Finland; Wilkman 1935)

2 Acid plutonic rocks, mica schists and gneisses with two or three dominant trends in the foliation: folded angulate image texture. (Fig. 4; west of Lake Päijänne; Laitakari 1973)

3 Narrow schist belt surrounding a granodiorite pluton: annular image texture. (Fig. 5) In the image the annularity is expressed by light cultivated patches along the schist belt while the granodiorite area, being forested, is dark. (South of Mäntsälä, southern Finland; Kaitaro 1956)

4 "Mantled gneiss dome": radial image texture. (Fig. 6) The texture appears inside a polygonal ring of cultivated land, about 5 km in diameter. At least part of the ring follows the schists along the dome boundary. (Kasurilanmäki Hill, 15 km north of Kuopio, central Finland; Wilkman 1935)

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

5 Varieties of rapakivi: rectangular image texture. (Fig. 7; south of Lappeenranta, southeastern Finland; Simonen 1975, Hackman 1934)

6 Pyroxene and mica gneiss with minor granite lenses parallel to foliation: striated image texture (Fig. 8; near Karkkila, southwestern Finland; Härme 1958)

7 Veined mica gneiss: parallel texture (Fig. 6; west of Kuopio, central Finland; Wilkman 1935)

8 Massive plutonic rocks free of systematic fractures are frequently characterized by a "kettle-hole" image texture (Fig. 9) caused by numerous small lakes. The example area consists of anorthosite, gabbro and granite. (Vuohijärvi, southeastern Finland; Lehijärvi and Tyrväinen 1969)

Ground Surveys

J. Nanyaro (1975) has examined some LANDSAT-1 lineaments in Finnish Lapland. He found that zones of cataclasis correlated with the lineaments. This suggests that the lineaments mark boundaries of dormant or active basement blocks.

Two small test sites in western Finland are being studied by J. Talvitie. Orientations of soil contours interpreted from LANDSAT images seem to correlate with faults and foliation of the bedrock.

Imagery data has been extended to other users and the data products are widely utilized in prospecting programs.

SIGNIFICANT RESULTS

On the central Baltic Shield the concept of drainage patterns can be extended to smaller scales in which case many cultural features become involved to the spatial patterns influenced by bedrock structure. Features resulting from agricultural activity and timbering often exaggerate the influence of the bedrock on the image texture. In Fig. 8 , for instance, chains of light-toned agricultural fields follow the strike of foliation of the gneissose bedrock.

REPORTS ETC.

An in-house report concerning visually interpreted image-textures at 68 different sites in southern Finland has been completed. (Räsänen 1975)

Vuorimiesyhdistys (The Finnish Society of Mining Engineers) has appointed a 5-member committee the function of which is to extend knowledge of remote sensing methods to Finnish geologists. The subject has been defined: "Remote Sensing and Prospecting". The P.I. (Tuominen) and two co-investigators (Aarnisalo and Talvitie) of program 28 600 are on the committee.

PROBLEMS

The following problems have been encountered in optical processing of LANDSAT images:

Problems encountered with diffraction in filters having sharp edges have made the use of apodized filters extremely desirable. These have proven difficult to to prepare. Both manual and computer methods are under

investigation to reduce this problem.

The matrix format of the images hampers the extraction of directional information.

REFERENCES

Hackman, V. (1934) Das Rapakivirandgebiet der Gegend von Lappeenranta (Willmanstrand). Bull. Comm. géol. Finlande 17, 106.

Härme, M. (1958) General geological map of Finland, Pre-Quaternary rocks, 1:400 000, sheet-B 1-Turku. Geological Survey of Finland.

Kaitaro, S. (1956) Geological map of Finland, Pre-Quaternary rocks, 1:100 000, sheet-2044-Riihimäki. Geological Survey of Finland.

Laitakari, I. (1973) Geological map of Finland, Pre-Quaternary rocks, 1:100 000, sheet-2144-Kaipola. Geological Survey of Finland.

Lehijärvi, M. and Tyrväinen, A. (1969) Geological map of Finland, Pre-Quaternary rocks, 1:100 000, sheet-3114-Vuohijärvi. Geological Survey of Finland.

Nanyaro, J. (1975) On the geology and lineaments of northern Finnish Lapland, with special reference to the Lemmenjoki and Ivalojoki gold districts. Unpublished master's thesis. Department of Geology, University of Helsinki.

Parvis, M. (1950) Drainage pattern significance in airphoto identification of soils and bedrocks. Photogram. Eng. 16, p. 387 (ref. Reeves, et.al. 1975).

Räsänen, J.(1975) Etelä-Suomen kallioperäkarttojen ja LANDSAT-kuvatekstuurien visuaalinen vertailu. (Visual comparison of geological bedrock maps and LANDSAT image textures in southern Finland.) In-house report for LANDSAT program 28 600. Department of Geology, University of Helsinki.

Reeves, R.G., Kover, A.N., Lyon, R.J.P., and Smith, H.T.V. (1975) Terrain and minerals: assessment and evaluation. Manual of remote sensing II, p. 1106. Amer. Soc. Photogram.

Simonen, A. (1975) Geological map of Finland, Pre-Quaternary rocks, 1:100 000, sheet-3131-Luumäki. Geological Survey of Finland.

Tuominen, H.V. (1975) Quarterly progress report I, LANDSAT follow-on investigation program 28 600: Investigation of Landsat imagery on correlations between ore deposits and major shield structures in Finland. NASA.

Wilkmann, W.W. (1935) General geological map of Finland, Pre-Quaternary rocks, 1:400 000, sheet C 3, Kuopio. Geological Survey of Finland.

TABLE 1 LANDSAT-2 images received by P.I. during Oct.-Dec. 1975 x

number in Fig. 2	image ID	clouds	date acquired	date received by P.I.	principal point	discipline
34	2264-08524	(30)	75-10-13	75-12-22	N 61 11 E 026 02	geology
35	2264-08521	(30)	75-10-12	75-12-22	N 62 33 E 027 09	"

cloud cover: a. given by catalogue
b. estimated by author

x
Continuation to Table 1 in Quarterly Progress Report I, Investigation Number 28 600

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

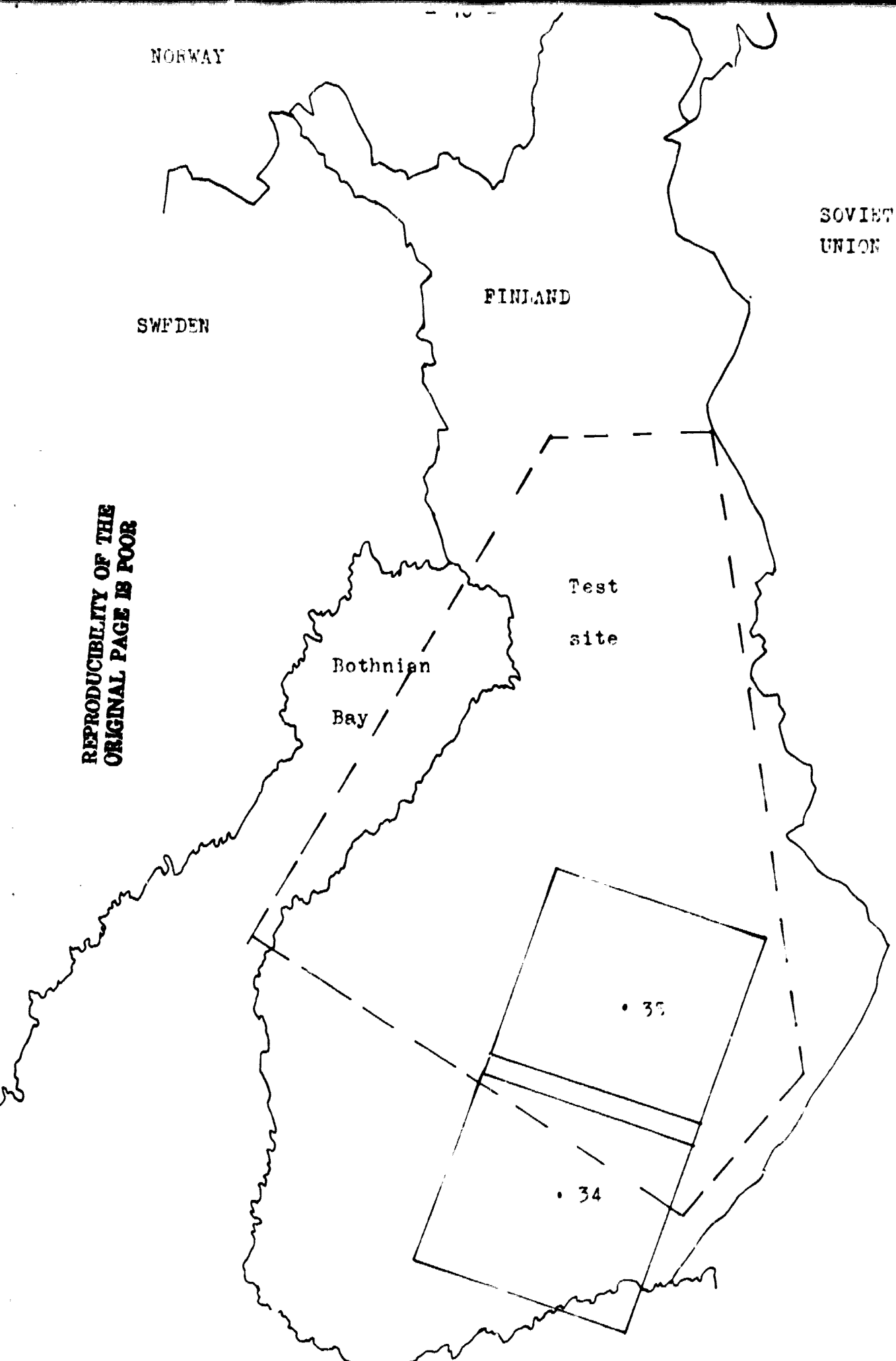
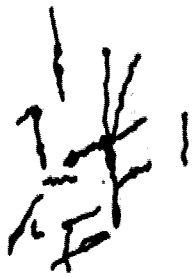


Fig. 1. Test site of the program 28600 and the coverage of the images received during the reporting period.

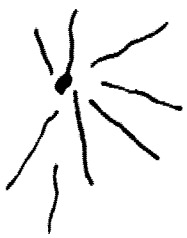


Angulate

Folded angulate

Parallel

Striated



Radial

Rectangular

Annular

Kettle holes

FIG. 2 Charasteristic image-textural patterns related to bedrock properties.

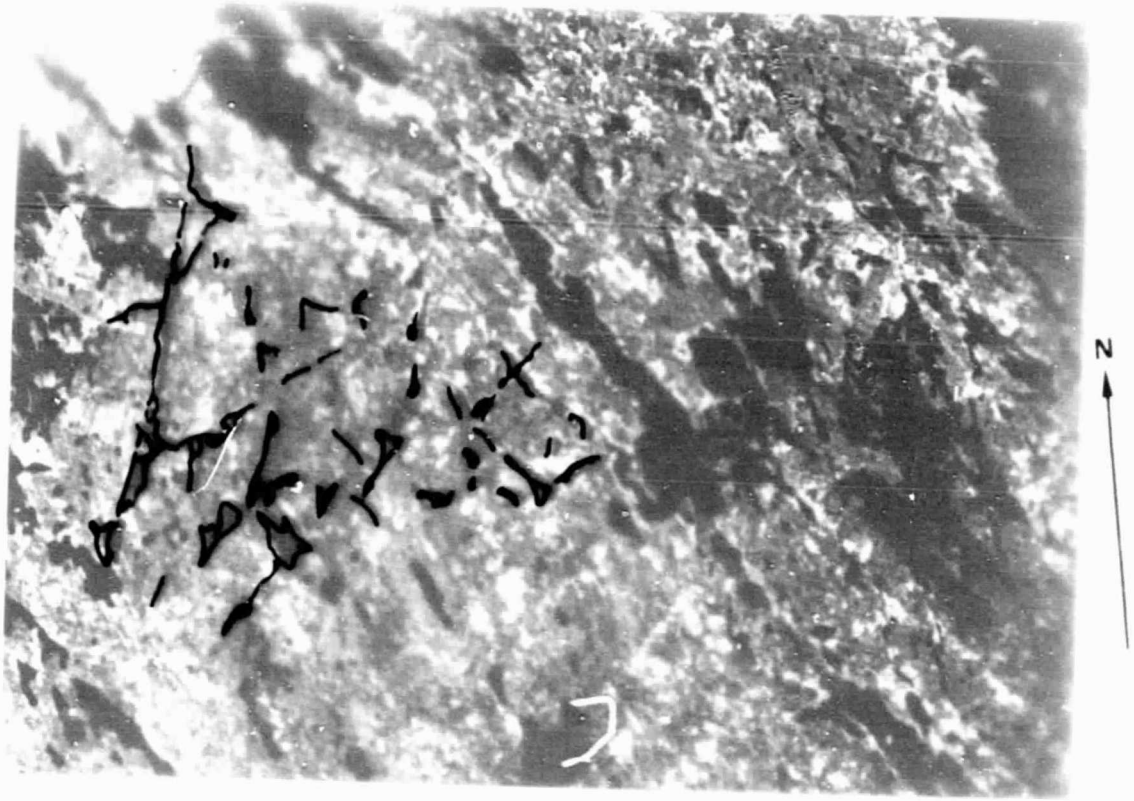


Fig. 3. Angulate image texture
Scene 2137-08480-7.

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

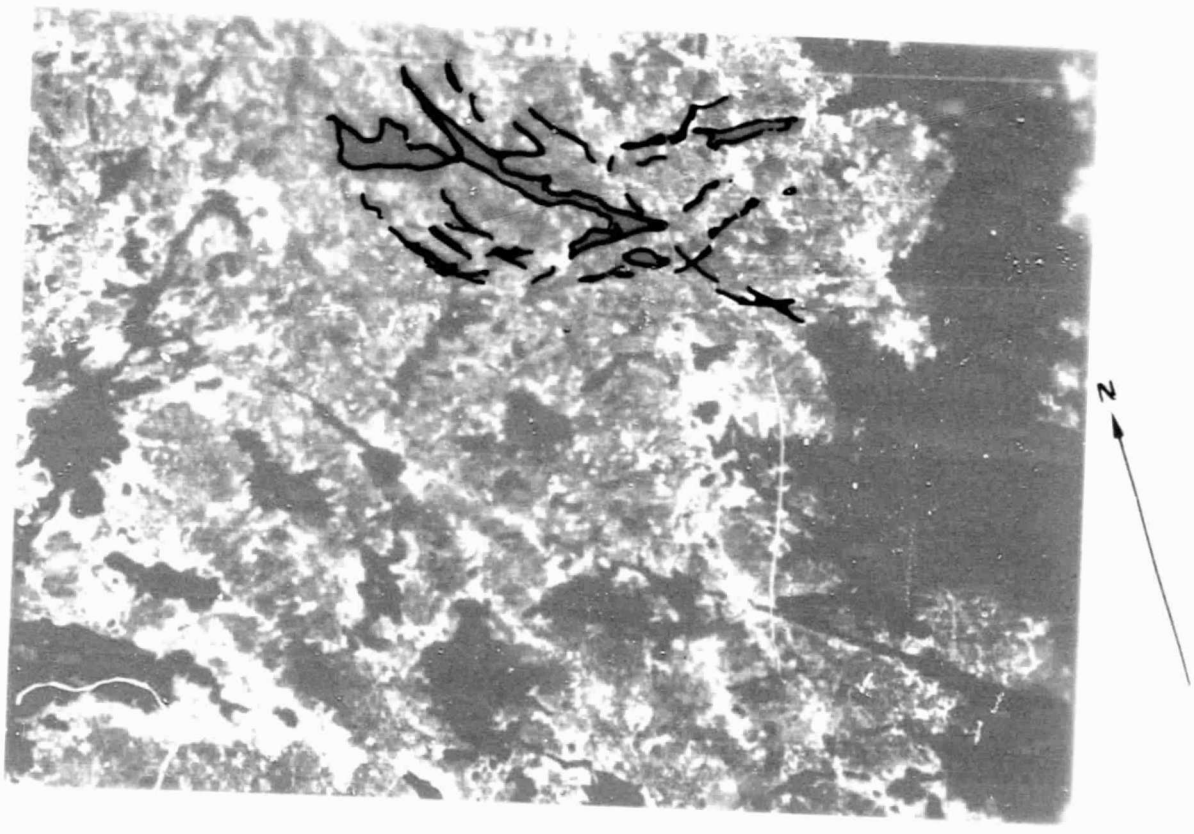


Fig. 4. Folded angulate image texture
Scene 2139-08595-7.

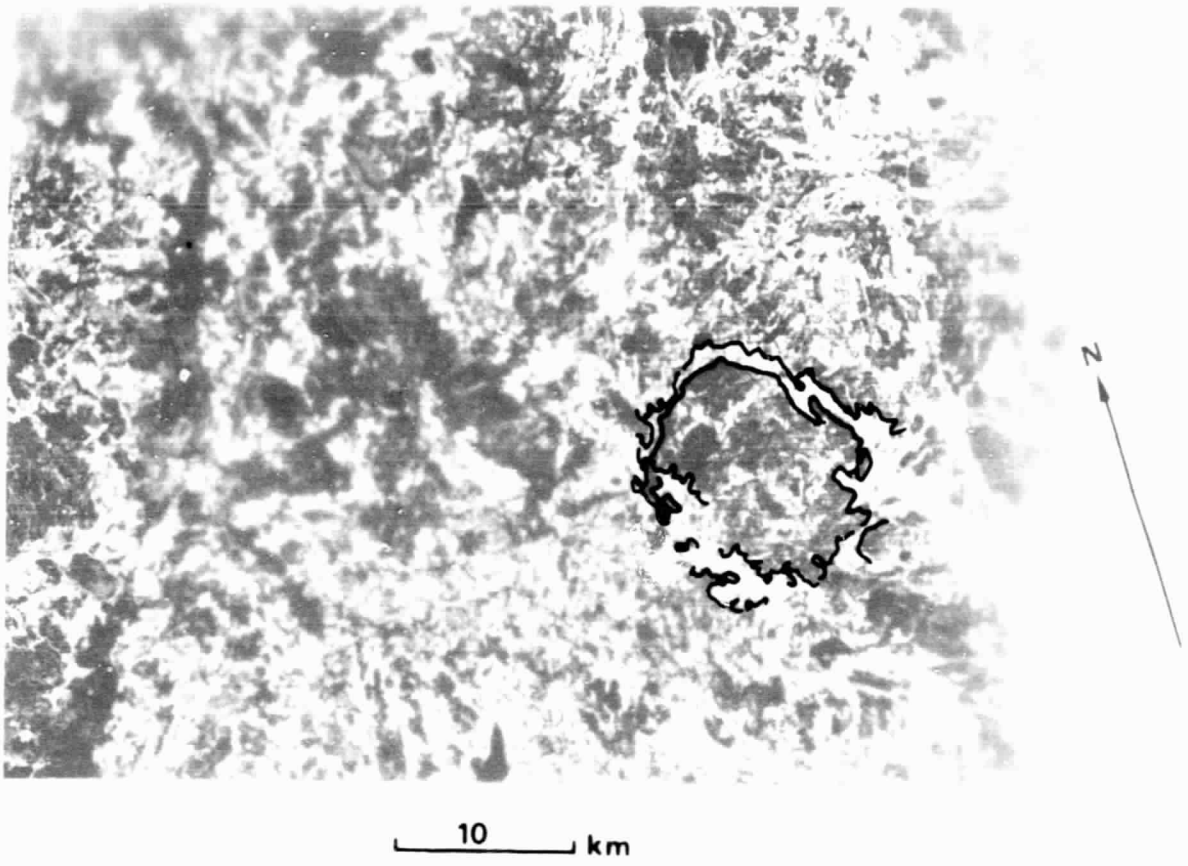


Fig. 5. Annular image texture
Scene 2139-08595-7

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

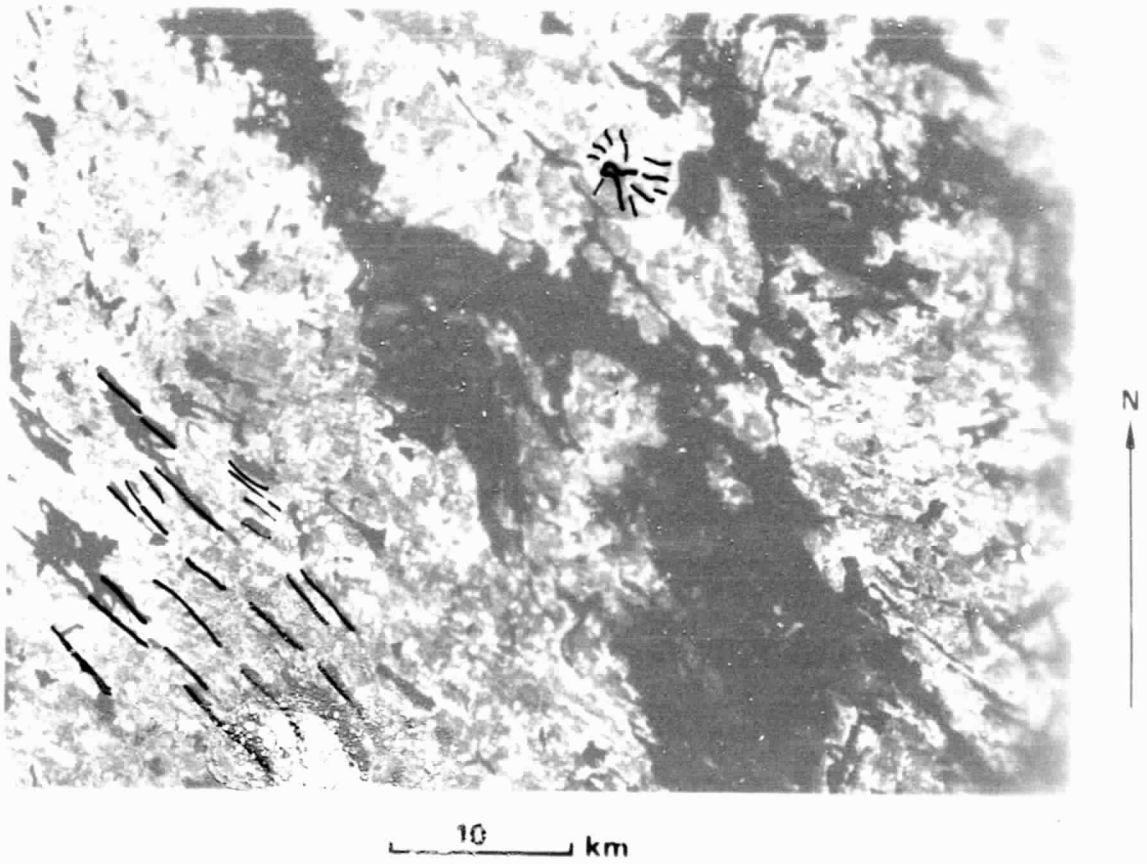


Fig. 6. Radial and parallel image textures
Scene 2137-08480-7.

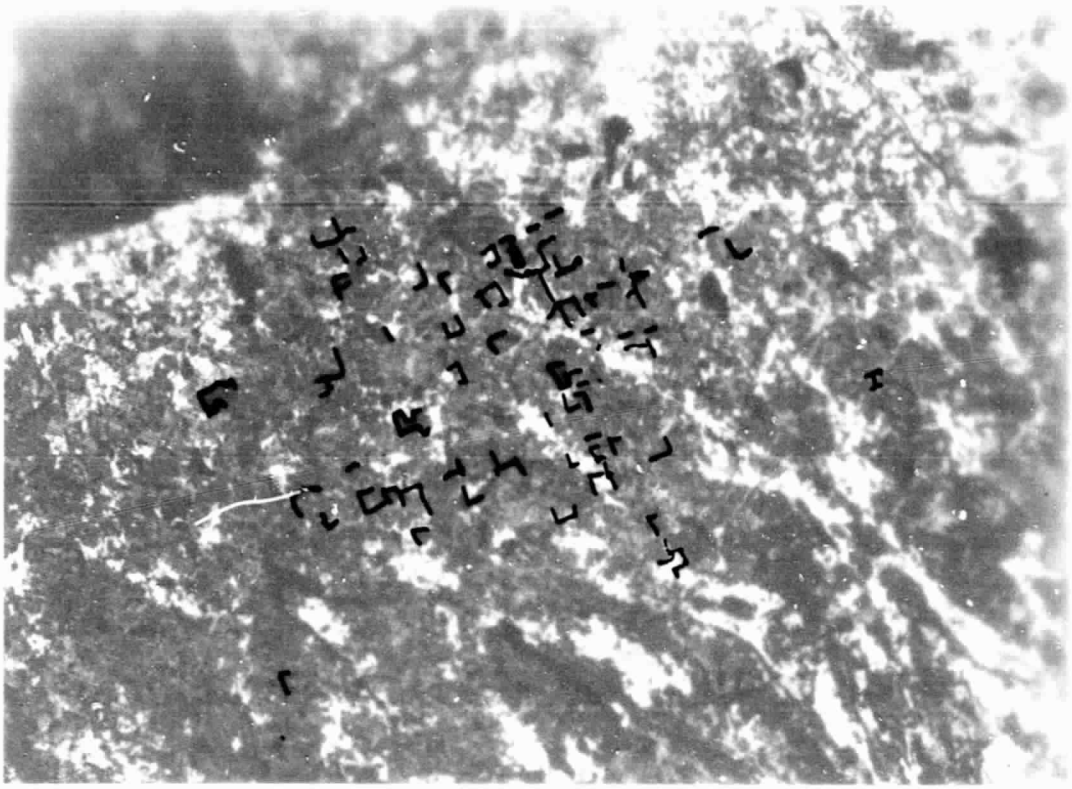


Fig. 7. Rectangular image texture
Scene 2137-08482-7.

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

Fig. 8. Striated image texture
Scene 2139-08595-7.

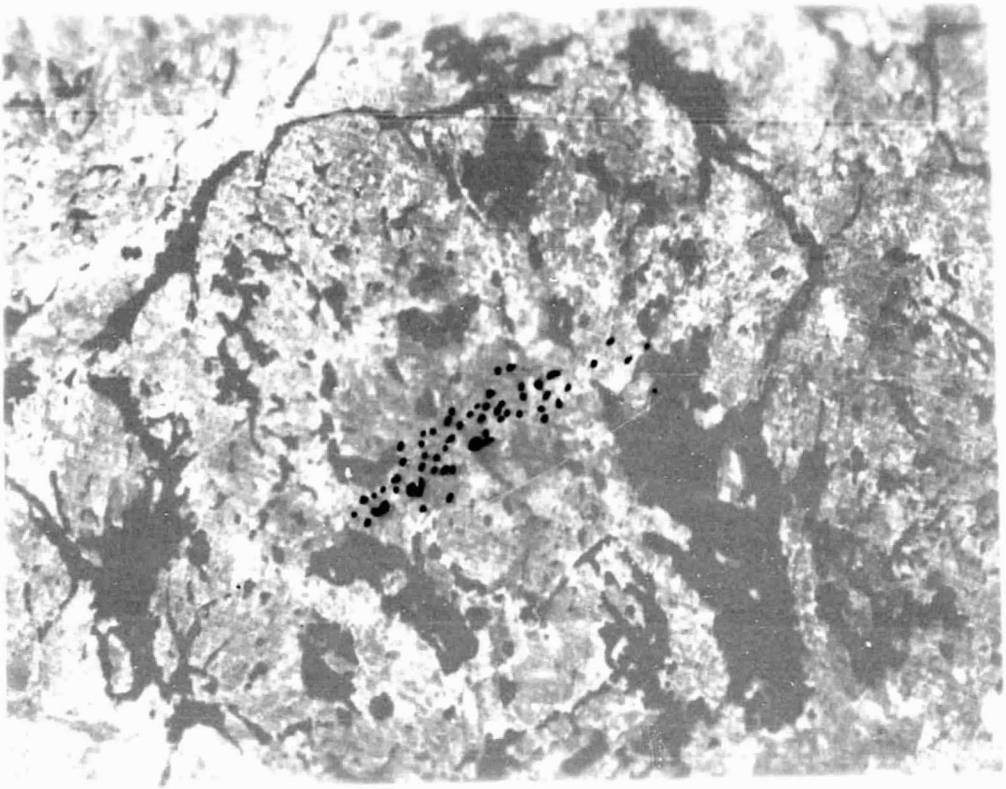


Fig. 9. "Kettle-hole" image texture
Scene 2137-08482-7.